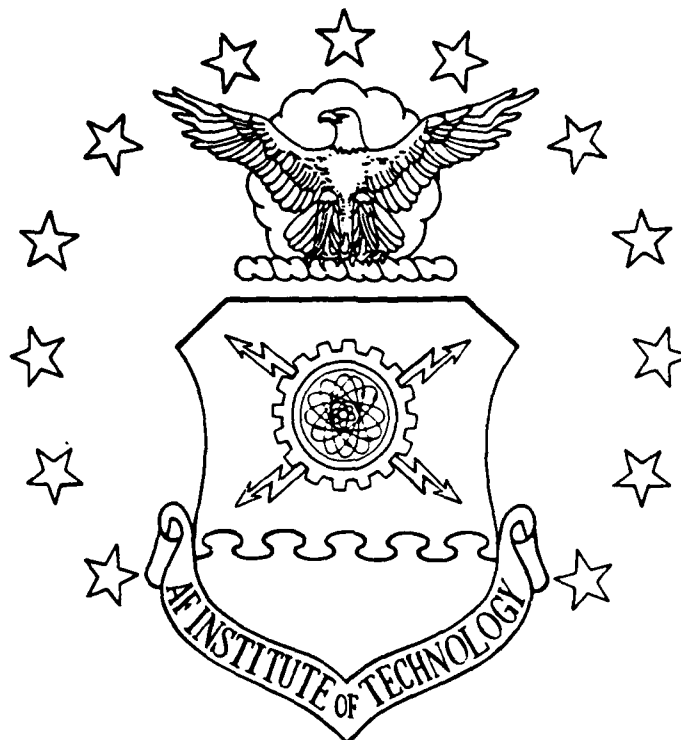


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IMPLICATIONS OF THE AIR FORCE  
RELIABILITY AND MAINTAINABILITY PROGRAM  
ON AFLC TRANSPORTATION

THESIS

Jeffrey J. Buckner  
First Lieutenant, USAF

AFIT/GLM/LSM/88S-6

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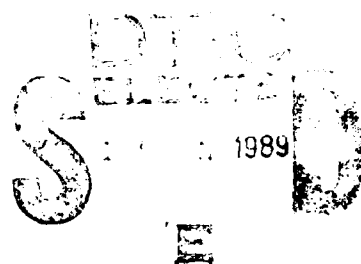
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IMPLICATIONS OF THE AIR FORCE RELIABILITY  
AND MAINTAINABILITY PROGRAM ON TRANSPORTATION

THESIS

Presented to the Faculty of the School of Systems and  
Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Logistics Management

Jeffrey J. Buckner, B.B.A.

First Lieutenant, USAF

September 1988

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Jeffrey J. Buckner

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Abstract

The object of this research is to provide a comprehensive overview of the Air Force Reliability and Maintainability (R&M 2000) Program's effect on Transportation in the area of Traffic Management and to look into future distribution trends to suggest areas of opportunity for Transportation to enhance its support of the systems subjected to the R&M 2000 process.

This study encompasses the impact of R&M on Air Force Traffic Management policy, attitudes, techniques, and issues. In addition to examining the changes being brought about by the R&M 2000 program, some of the developments in transportation and logistics management that are occurring parallel to the R&M 2000 program are also discussed.

Results of this investigation indicates that the institutionalization of the R&M 2000 program has not progressed to the level needed to influence Transportation policy. AFLC has created a Process Action Team (PAT) to address this situation. The characteristics of the PAT are discussed, along with relatively recent developments in distribution and Transportation, such as the European Distribution System (EDS) and LOG-X.

IMPLICATIONS OF THE AIR FORCE  
RELIABILITY AND MAINTAINABILITY PROGRAM  
ON AFLC TRANSPORTATION

I. Introduction

General Issue

The defense of the United States is faced with numerically superior forces. The Soviets and their allies have both more personnel and weapons than the U.S. and its allies. For example, when comparing the North Atlantic Treaty Organization (NATO) forces to Warsaw Pact nations forces, there is nearly a 3-to-1 advantage in fighter aircraft and a 6-to-1 advantage in interceptor aircraft (15:159). To combat this situation weapon systems must perform with sustained operational performance over time. This means that a weapon system not only has to function properly but must do so over a longer period of time than the equivalent weapon systems of the enemy.

Improved reliability and maintainability (R&M) of Air Force systems is one of achieving enhanced operational performance and acts as a force effectiveness multiplier (11:1). For example, if a fighter aircraft that is taken out of action because of mechanical failure can be put back into service quickly, there is a 1.5 multiplier effect. This is because there is now a functional fighter where there would have been one less aircraft otherwise.

The Air Force Reliability and Maintainability Program, R&M 2000, was developed to institutionalize the Air Force's commitment to improving R&M of weapon systems. Policies, attitudes, and techniques in the acquisition and other logistics processes that improve R&M are key to achieving gains in combat capability.

The R&M 2000 has a specific impact on the acquisition and maintenance of weapon systems. From a holistic viewpoint, R&M 2000 should affect all logistics functional areas as well as direct acquisition and maintenance of weapon systems. Logistics is composed of both processes and functions. Logistics process are comprised of planning, acquisition, distribution, conservation, and disposition. Logistics functions are Procurement, Transportation, Supply, Maintenance, Logistics Plans, Defense Property Disposal Office (DPDO), and Military Aircraft Storage and Disposal Center (MASDC). There is a matrix relationship between the processes of logistics and the functions of logistics. For example, as a process such as planning is executed, it effects the way in which the functional areas operate. Conversely, as the capabilities or limitation of the functional areas effect the way in which the processes, such as planning, can be carried out. As a process such as the R&M 2000 program is introduced into this logistics matrix it is logical to assume that it impact all of logistic processes and functions. One aspect of logistics that

should be effect is Transportation's role in the R&M 2000 program.

R&M 2000 effects Transportation in two areas. One area of Transportation that is affected by R&M 2000 is Transportation's role as a conservator, maintaining and operating motor vehicles. The other area is transportations role as a distributor, moving both manpower and equipment in support of mission requirements.

In its role as a distributor, Transportation is directly affected by one of the primary goals of the R&M 2000 program, which is to decrease mobility requirements per deploying unit. By decreasing mobility requirements transportation assets can free up for other uses. Increased reliability and maintainability should also decrease support requirements for the movement of spare parts. This is because fewer spares will be required to support weapon systems as their reliability increases. While one would expect a decrease in transportation support in this situation it may well be that new, unforeseen requirements emerge from the R&M 2000 program. For example, a lower frequency of spares usage may cause lower stock levels throughout the whole system. This may require an increase in express freight services or require development of a "just-in-time" inventory system to support the weapon systems.

### Specific Problem

If R&M is to be successfully institutionalized, an integrated, strategic approach needs to be considered. This approach should incorporate all functional areas, from the actual engineering of a weapons system to long term logistical support. These and other R&M issues have direct implications for Transportation.

The problem is that currently there is no specific guidance dealing with the impact of the R&M 2000 program on Transportation, specifically its role as distributor. Such guidance should address are the implications of R&M 2000 with regard to its effect on Traffic Management issues, policy, attitudes, and techniques?

### Investigative Question

In order to understand the transportation implications of R&M 2000, the following questions need to be answered.

1. How have DoD and Air Force R&M directives effected transportation policy in the area of traffic management?
2. Have R&M directives and initiatives effected the requirements for expedited shipments of spares?
3. Do Air Forces transportation managers have any specific R&M programs and if so what are they?
4. What innovations in distribution management are being implemented to enhance R&M objectives?
5. What new developments in distribution management should the Air Force utilize to enhance R&M support of more reliable and maintainable systems?

### Scope

The scope of this study encompasses the impact of R&M on Air Force traffic management policy, attitudes, techniques, and issues. In addition to examining the changes being brought about by the R&M 2000 Program, some of the developments in Transportation and logistics management that are occurring parallel to the R&M 2000 program are also discussed.

### Research Objectives

The objective of this research is twofold. First, it provides a comprehensive overview of R&M 2000's effect on Transportation in the area Traffic Management. Secondly, this research looks into future distribution trends to suggest areas of opportunity for Transportation to enhance its support of the systems subjected to the R&M 2000 process.

### Literature Review

Literature on reliability and maintainability was found in a number of sources. However, specific information dealing with R&M's relationship with Transportation was conspicuously absent from the literature reviewed. The primary source of information on R&M was found in applicable Department of Defense and United States Air Force publications. In addition, a review of relevant material dealing with the proposed research subject was also

conducted in order to provide a background for Transportation role in logistics and R&M. It also provides a framework for Transportation planning necessary to deal with environmental changes, such as, the R&M 2000 program.

Applicable Regulations. The primary source of direction for all DOD Reliability and Maintainability programs is Department of Defence Directive (DODD) 5000.40. The general policy concerning R&M as stated in DODD 5000.40 is as follows:

Reliability engineering shall focus on the prevention, detection and correction of design deficiencies, weak parts, and workmanship defects. Maintainability engineering shall reduce maintenance and repair time, number of tasks required for each preventative and corrective maintenance action, and the need for special tools and test equipment. Program plans shall stress early investment in R&M engineering in order to avoid subsequent cost and schedule delays [12:2].

Transportation, while not a direct component in early reliability engineering or in maintainability engineering, has a direct impact on the reduction of repair time. This manifests itself in the form of Transportation's role in the timely and efficient movement of spares to where they are needed in a safe and serviceable manner.

DODD 5000.40 further states that "The DoD components shall define fundamentals of design, manufacture, and management which will result in delivery of reliable and maintainable items to the operational forces" (12:2). The design of a system should not be limited to its physical design but should be an all encompassing approach to design.



This means that the actual design of a weapons system should include the support requirements for that system as well. Without consideration for support requirements, such as transportation, the objectives of R&M could be undermined by inadequate or antiquated support structures.

In response to DODD 5000.40, the Air Force R&M 2000 Program was developed by direction of the Secretary of the Air Force and Chief of Staff of the Air Force. The program set six specific objectives as follows:

1. Provide clear direction aimed at increasing reliability and maintainability of Air Force systems to increase weapon system combat effectiveness.
2. Focus organizational attention and expand training to build the reliability and maintainability technical expertise, advocacy, authority and accountability throughout the Air Force.
3. Improve reliability and maintainability planning to consolidate efforts, tie reliability and maintainability to operational goals, and coordinate major command efforts to accelerate improvements in weapon system reliability and maintainability.
4. Establish internal administrative systems in order to ensure effective accountability and feedback to measure progress in the reliability and maintainability improvement program.
5. Provide positive communications and motivation to sustain commitment to the support for reliability and maintainability requirements.
6. Obtain and sustain industry commitment to ensure that contractors have the motivation and capability to support reliability and maintainability requirements. [8:2]

Five goals have been established to achieve the objectives of the R&M 2000 plan. These goals are:

1. Increase warfighting capability.
2. Decrease the vulnerability of the combat support structure.
3. Decrease mobility requirements per deploying unit.
4. Decrease manpower requirements per unit of output.
5. Decrease costs. [1:1]

While all of these goals have an impact in some way on Transportation, goals three and five have the most direct impact. As there is a shortfall of airlift, decreased mobility requirements will free up transportation assets for the movement of other necessary supplies. For example, the F-15E Mobile Electronic Test Set (METS) has one-seventh the weight and one-eighth the volume of the corresponding stations in the original F-15 Avionics Intermediate Shop (AIS). The entire METS deploys on a single pallet. This represents an airlift savings of one C-141 aircraft (11:5). If the system can be made more reliable and maintainable it will require less transportation support thus contributing to the final goal of decreasing costs.

The Air Force Regulation intended to implement DoDD 5000.40 and the Air Force R&M 2000 action plan is Air Force Reliability and Maintainability Policy, AFR 800-18. This regulation restates the goals as put forth by the Air Force R&M 2000 action plan. It also establishes policies and responsibilities for ensuring that R&M are primary considerations throughout the lifecycle of Air Force systems

(8:1). This policy includes applying certain fundamentals of design, manufacture, and management to ensure delivery of reliable and maintainable systems to the operational forces (8:2). These fundamentals are to "include R&M requirements for support equipment, training equipment, and other support elements in the overall system program" (8:3).

Transportation support is one of the other support elements that should be included in the overall system. Without consideration of transportation requirements for any system, a reliable system could be made unreliable simply because transportation support was not figured into the R&M equation.

A good explanation of the entire R&M 2000 process is given in the USAF R&M 2000 Process booklet prepared for the Office of the Special Assistant for Reliability and Maintainability. In addition to restating R&M 2000 goals the booklet provides a discussion of "R&M 2000 Process Principles and Building Blocks" as well as a discussion of application of the R&M 2000 Process to Air Force programs.

There are five R&M 2000 principles. They are management involvement, motivation, requirements, design and growth, and preservation (11:10). There are 21 R&M 2000 Building Blocks which directly support these different principles (11:11). The "Systems Engineering Process" building block is where any transportation considerations would be brought into the process. The systems engineering

process is in direct support of the design and growth principle, and as with all the building blocks of the R&M 2000 process, supports the principle of management involvement in the R&M 2000 process.

"The Systems Engineering Process integrates design, R&M, Logistics, and production engineers into a team committed to delivering products that meet the user's requirements at a reasonable cost" (11:57). Supportability personnel should be part of the design team and should participate in the design reviews and tradeoff studies throughout the program. This way the system can be economically produced as designed and engineered-in R&M can be retained after production (11:59).

Transportation Issues. The primary logistics support function of interest for this research is Transportation and issues dealing with Transportation. Transportation factors are significant with regard to the design of a system for transportability or mobility (3:63). In Blanchard's book, Logistics Engineering and Management, he states that transportation plays a key role in the area of logistics support. To this end transportation factors are considered in an integrated logistics support plan.

The Transportation and handling plan is developed to cover the basic distribution and transportation methods/procedures for the shipment of system components from the producer to the consumer, for the shipment of elements of logistic support to operational sites, and for the shipment of items requiring maintenance support [3:335].

In Stock and Lambert's book, Strategic Logistics Management, transportation is identified as one of the areas in which logistics performance can be improved. As transportation usually represents the largest single logistics expense, methods of improving management of the transportation activity need to be examined (31:65). Stock and Lambert further point out that transportation productivity gains come primarily through improved effectiveness (31:257). "There are only two ways to be productive: doing things right and doing the right things. The former is what we call efficiency, the latter, effectiveness" (24:21).

As R&M 2000 brings about the changes in system design, Program Development Managers will be forced with two choices: they can merely react to these changes or they can plan for them. The former course will entail improved efficiency, the later (and more desirable) improved effectiveness. Transportation and physical distribution management will either have to react to changes brought about by R&M 2000 or can plan for the changes. Strategic planning allows transportation managers to anticipate change rather than react to it. One method of strategic transportation planning is posed by Temple, Baker and Sloane in Transportation Strategies for the Eighties. In the planning process seven steps are identified. In the first step, a transportation audit is conducted to provide

essential inputs to the planning process. These inputs include current effectiveness and efficiency of transportation activities, baseline information to evaluate alternative strategies, and key strategic issues (32:15).

The second step in the transportation strategy planning process is development of a "base case" projection for transportation system performance. The "base case" defines the bench marks against which potential changes in transportation strategies can be measured. Baseline information from the transportation audit provides information for this step (32:17).

The third step in the process is analysis of critical trends and identification of key strategic issues. Performance evaluations, specification of logistics strategies and associated resource plans, and implications of external forces are drawn together to identify the key strategic transportation issues (32:17).

Step four involves formulation and evaluation of strategic response options. This step requires the most imagination and creativity. For each key issue potential courses of action are identified and evaluated (32:17).

Step five is the preparation of a strategic plan or alternative plans. In this step the response options are integrated into a single plan or alternative plans (32:17).

The sixth and seventh steps are, respectively, the evaluation and approval of the strategic plan, and the

actual implementation of the planned action. The approval step is to get the blessings of senior management.

Implementation turns the plan into action and involves a continuous process of monitoring progress, and developing information to be used in the next round of strategic planning (32:18).

This process shows one way to approach the uncertainties of future transportation issues, including those imposed by changes brought about by R&M 2000. Anticipating change is the key to strategic planning. By using an approach similar to the one mentioned above, Transportation planners will be able to incorporate factors contributing to change, ie. R&M 2000.

The Japanese, whom are known for producing high quality and reliable products, have a very broad view of what constitutes reliability. Figure 3.1 graphically shows how they brake down operational reliability (Ro) into elements for evaluation. As can be seen from the diagram, Ro is broken down into two specific types of reliability. Inherent reliability (Ri) has to do with the actual design and manufacture of an item. Use reliability (Ru) is where such things as the actual use of the item comes into play along with maintenance, and environmental factors. Inherent reliability multiplied by use reliability equals operational reliability (21:10).

Transportation or, as the diagram shows, shipping falls under the environmental factors as a part of use reliability. Packaging, a transportation function, is also listed under environment. Considering the number of people and transportation devices to which a product is exposed, it is readily seen that Transportation is a very important factor in maintaining reliability (21:115).

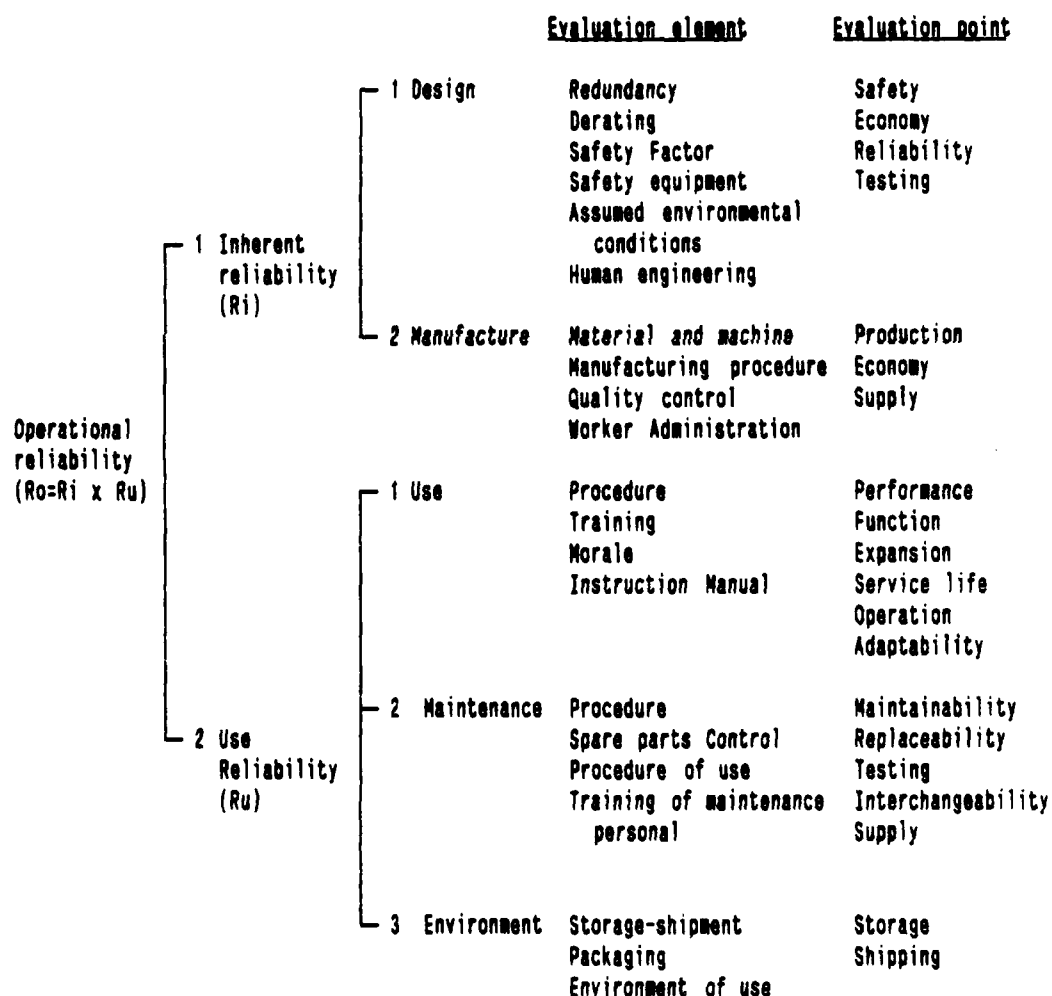


Figure 1. Areas of Reliability and Evaluation (21:10)



### Summary

While specific direction for Transportation is absent from applicable DOD and Air Force regulations and directives, there is a clear understanding of the need to integrate support requirements in the R&M process. Transportation represents a significant link in the logistics support chain and is recognized as such by leaders in the logistics management field. Transportation strategic planning has also been discussed and shown to be a valuable tool in dealing with changes that may be brought about by the R&M 2000 Program. Additionally, in taking a broader view of total operational reliability, the Japanese have recognized the need to protect inherent reliability with equal consideration of use reliability. Planning in the Transportation area can and must be accomplished to enhance the support provided to the new systems produced through the R&M 2000 program.

## II. Methodology

### Particular Method

This research was exploratory in nature. As such, HQ AFLC was chosen as a representative sample of a command dealing with R&M issues on a day to day bases. HQ AFLC was selected on the bases of its leadership role in the R&M arena (7) and its relatively convenient accessibility. The information for this research will be gathered from published material and through personal contact with individuals at agencies dealing in the subject areas.

In order to answer the investigative questions both a literature review of past practices in traffic management and a review of post R&M 2000 practices was accomplished. This review covered existing regulations and directives as well as information supplied by interviews with Air Force personnel from the functional areas dealing with R&M. The interviews were relatively unstructured to promote a free-flowing exchange of thoughts and ideas. Questions asked in each interview were tailored for the particular area being reviewed. The method of interview allowed for immediate follow-up questions and new questions brought about through the interview process.

The primary regulations providing information for this study are DoDD 5000.40, Reliability and Maintainability, and AFR 800-18, Acquisition Management: Air Force Reliability

and Maintainability Policy. Support information was obtained from the USAF R&M 2000 Process booklet and a fact sheet on "Air Force Reliability and Maintainability Program". Personal in positions of responsibility were interviewed to accomplish the bulk of the research. The Air Force Logistics Command, Deputy Assistant for R&M, HQ AFLC/MM-R was contacted to obtain information on present direction of the Air Force R&M program and for trends that may affect transportation. In addition to Headquarters personal, Transportation and Distribution managers were also interviewed for their insights into the impact of R&M 2000 on transportation.

To assess the current trends in transportation management, literature dealing with distribution and logistics principles was reviewed.

The most significant hurdle anticipated is the lack of data dealing with R&M 2000's relationship to traffic management. While there appears to be significant data dealing with R&M 2000 and its application to acquisition and maintenance functions, there does not seem to be a very large data base dealing with R&M 2000's relationship to support functions such as traffic management.

### III. Findings and Discussion

In this chapter, the impact that R&M 2000 has had on Transportation will be examined. Of primary concern to transportation is the impact of R&M on mobility, number of spares, and the shipment of spares, as well as some of the parallel developments in Transportation and Logistics. The developments in Transportation and Logistics sections of this chapter will examine existing policy. Additionally, innovative management techniques such as Just-In-Time (JIT) inventory systems and Material Requirements Planning (MRP) will be discussed in order to examine the applicability they might have in enhancing R&M objectives. Finally, the implications for transportation policy will be discussed.

#### Mobility

There is currently a national policy goal of a minimum airlift capacity of 66 million ton miles per day to support theater commanders who must actually go to war (4:22). Reliability and maintainability could have a dramatic effect on the mobility of our systems by reducing the number and types of personnel, equipment, and spares necessary to deploy in support of combat units. This would go a long way toward moving actual available capacity closer to the minimum airlift requirements. Decreasing mobility requirements, as mentioned earlier, is one of the goals of R&M 2000 as well. In a Rand study of F-15 intermediate

avionics, a four-fold improvement in reliability of 11 line replaceable units (LRU's) (10% of the avionics LRU's in the aircraft) would eliminate the avionics intermediate test station for a squadron deployment. The resulting mobility payoff would be 22 fewer pallets of cargo and 40 to 50 less maintenance personnel per squadron (20:11).

#### Number of Spares

Closely related to the impact R&M has on mobility is its impact on the number of spares required by a given weapon or support system. By improving reliability, system failures are reduced, lessening the need for spares (19:11). There is general agreement among those interviewed that the total number of spares should decrease as the R&M 2000 program begins to show results. As of yet it is impossible to assess just how much of a decrease will occur as each system is different with different requirements.

Utilization rates for spares is generally the driving force behind spares requirements and actual decreases in those requirements won't be felt until utilizations rates for a particular spare decreases. When utilizations rates decrease the total number of spares required decreases.

#### Shipment of Spares

As of yet the shipment of spares has not been affected by the R&M 2000 program (17). "We're in the you call, we haul type of business" according to Andy Figueroa, Chief of

Transportation Management, AFLC/DSTT. He does not expect this to change significantly due to the R&M 2000 program. Mr. Figueroa does feel that if inventory levels are reduced, this will mean more transportation will be required which is the traditional result of reduced inventories.

The most direct impact R&M 2000 on Transportation is felt in the area of packaging. This manifests itself in two forms. First, the packaging of spares plays a fundamental role in insuring that a shipment arrives at its destination in a safe and serviceable manner. Secondly, the mode of transportation can have a direct impact on what kind of condition a shipment arrives in. For example, when the F100 jet aircraft engine was originally shipped, it was going via a standard type of truck/trailer combination. The resulting vibration caused unseen damage to the engine resulting in an unacceptable failure rate for the engine. In order to remedy the problem, future shipments were shipped via specialized, air-ride trailers which reduced the vibration. As a result, the failure rate was greatly reduced (36). This illustrates how a complex, highly technical aircraft engine can be affected by something that was not considered in its design. The stresses brought on by transporting the engine by truck proved more damaging than the stresses the engine experienced in actual use.

One of the fears in using packaging in order to accomplish greater reliability is that over packaging

increases material costs and that more packaging usually results in larger, heavier packages that consume more resources to move (17). Both increasing cost and taking up more space are counter to the goals of R&M 2000. Increased packaging for increased protection must be weighted against the benefit it's supposed to accomplish.

#### Existing Transportation Policy

Basic Air Force transportation policy is derived from Air Force Regulation (AFR) 75-1, Transportation and Traffic Management, Transportation of Materials. In determining the mode of Transportation to be used, the following guidance is given:

The basic policy in selecting the mode and method of transportation (rail freight, water carrier, motor carrier, postal, air carrier, and so forth) is to use the method that will get the items delivered at the final destination within Uniform Material Movement and Issue Priority System (UMMIPS) standards at the lowest overall cost to the government [10:8].

The UMMIPS provides a ready basis for expressing the relative rank of requisition and material movement. A series of two-digit codes (priority designators) provides a means of assigning relative ranking to competing demands. The priority designator is based upon two factors related to the mission of the requestor. The Force/Activity Designator (FAD) is assigned by the Secretary of Defense, the JCS, or by a DoD component. The Urgency of Need Designator (UND) is determined by the requisitioning activity. The FAD and UND

combine to determine the priority designator as expressed in Table I:

Table I. Table of Priority Designators (13:Encl 3:4)

<u>Force/Activity Designator</u>	<u>Urgency of Need Designator</u>		
	<u>A</u>	<u>B</u>	<u>C</u>
I	01	04	11
II	02	05	12
III	03	06	13
IV	07	09	14
V	08	10	15

To determine a shipments priority designator from Table I, the UND of the requisition or shipment is matched to the units FAD. For example, a unit with a FAD of I and UND of B would have a priority designator of 04. If the UND is upgraded to A, the priority designator will move to 01. The priority designators are then used to determine what Transportation Priority (TP) a shipment will have. TP-1 is for shipments with a priority designator or 01 to 03. TP-2 is for shipment with a priority designator of 04 to 08 and TP-3 for shipment with a priority designator of 09-15 (10:94).

A possible requirement that the R&M 2000 program could generate would be to increase the need for expedited shipments because inventories of spares would be reduced as a result of higher reliability. Expedited, or Transportation Priority 1, shipments are covered by "999" procedures.

The 999 procedures pertain to those critically needed items with transportation priority 1 that are required to remove primary weapon and equipment from Not Mission Capable Status (NMCS). Requisition submitted by



overseas activities with assigned Force Activity Designators (FAD) I, II, or III, and requisitions from CONUS activities with assigned Force Designators (FAD) I, II, or III scheduled for overseas deployment within 30 days are eligible for expedited processing under 999 Procedures [10:48].

As can be seen from the above description, it is the requisition priority that drives the need for expedited shipments. Without a change in policy, it does not seem likely that R&M will have an impact on expedited transportation requirements unless the program causes a change in the FAD assigned or if it causes the UND to be upgraded. While it is unlikely the FAD will be changed, a UND upgraded is possible anytime a unit has a critical need. In a situation where a unit is FAD II and out of spares because R&M has reduced the number of spares on hand, a UND A would result in a 03 priority designator and a Transportation priority of 1. This would make the shipment eligible for "999" procedures if it is in NMCS.

The standards for expedited shipments that are currently established by the UMMIPS may need to be revised in order to support R&M 2000 goals. The fastest required delivery from requisition submission to receipt take-up by the requisitioner is 12 days to the Western Pacific and 11 days to the rest of the world (13:4). Whether these standards will be sufficient to support R&M 2000 objectives have not as yet been addressed (18).

### Just-in-Time Systems

In looking for ways to improve the current distribution system in order to better support R&M 2000 objectives, some relatively recent innovations in distribution were examined.

Just-in-Time (JIT) systems have become much more prevalent in manufacturing and logistics operations in recent years. JIT is an expansion of the Kanban system developed by the Toyota Motor Company during the 1950s and 1960s (Kanban are 3 1/2 inch by 9 inch signboards that help keep track of constantly changing production information.) (29:74). JIT combines purchasing and procurement, manufacturing, and logistics. The primary goals of JIT are to minimize inventories, improve product quality, maximize production efficiency, and provide optimal customer service levels (31:448).

Japanese auto manufactures have achieved phenomenally low inventory levels using JIT. For example, Mazda Motor Corp. boasts inventory levels of less than 30 minutes of production for essential components like carpet, ceiling and tires (28:74). Much of this success has been attributed to the close proximity of main assembly plants to parts suppliers. This fact coupled with the historically strong ties between suppliers and assemblers is what makes the Japanese system work. In a survey of companies using the JIT system in this country, the close relationship between supplier and buyer was restated as the secret to JIT success

(30:20).

JIT looks like it might offer some guidance for R&M responsive distribution systems. It is oriented toward support of operations with little inventory levels, which is one of the results that R&M is attempting to achieve. Unfortunately there appear to be some obstacles. The Air Force must deal with long supply lines and the nature of military procurement makes a close relation with suppliers very difficult (i.e. sealed bidding and competitive negotiation).

Close proximity and close supplier relations are not the only obstacles to a JIT system in the Air Force. Because JIT is a philosophical approach rather than a packaged solution, a number of established beliefs such as the idea that economic order quantities for lot-sizing is the optimum way to confront inventories for all types of operations. Another belief challenged by JIT is the idea that sourcing from several vendors for every type of purchase always results in the best price (27:98). This is a problem that is being wrestled with in the acquisition arena by those wishing to use competition to the maximum extent possible and those that would like to see more negotiation used in obtaining spares and weapon systems (5:54).

A&D Carriers. Manufacturers and suppliers in the Continental United States (CONUS) do not enjoy the same

geographic closeness that the Japanese have. This creates the problem of long supply lines. One solution to this problem has come about with the advent of Assembly and Distribution (A&D) carriers. These carriers, which have only been able to operate since deregulation of the Motor Carrier Industry in 1980, offer fast, high service linehaul transportation from distant suppliers to manufacturers or end-markets, often skipping echelons in traditional freight consolidation systems. (2:68)

There are five key aspects that distinguish the innovative, carrier-based A&D operations from more traditional facility-based or pure Less-Than-Truckload (LTL) carrier consolidation offerings and make them a preferred transportation option for long supply line JIT logistics channels. First, the new operations generally are designed to serve groupings of LTL shipments and high-service-level origin/destination pairs in shipper or receiver distribution channels. For example, in an Air Force depot repair sitting, this would involve having the A&D carrier make pickups from various suppliers, consolidate the load and shipping the material directly to the depot. Second, because A&D carrier operations involve one less breakbulk and pickup and delivery operation than traditional LTL carriers, it can generate cost savings. Third, A&D operations can ensure high service levels from suppliers to customers that require frequent but small shipments over

long supply lines. Generally, firms using A&D operations reduce average LTL shipment times by 25 to 50% depending on the competing LTL carrier network configuration (2:76). Forth, A&D operation gives most customers the control and flexibility to alter or redesign shipment practices quickly (2:76). Finally, the new carrier A&D operations often are run by an entrepreneurial owner or manager who is well versed in the shippers logistics requirements (2:77). As mentioned earlier, a close relationship with suppliers is essential for a successful JIT system. The same holds true for having a close relationship with the operation handling the transportation.

The principal competitive advantage that the new A&D motor carriers have over facility-based and LTL carrier consolidation services is the ability to provide superior transportation services at lower overall costs. A&D rates are 15 to 47% lower than single-shipment LTL rates. In addition, A&D carriers are often 25 to 50% faster than either LTL motor carriers or facility-based consolidators for the same shipment, especially over long distances (2:77). If the Air Force could use an A&D carrier, it would help to solve at least part of the problems with using JIT in the Air Force, at least within the CONUS.

#### MRP, MRP II, and DRP

Another system that may help transportation in the future to deal with any new requirements brought on by the

R&M 2000 program is MRP or MRP II. Computer-based materials requirements planning (MRP) systems were specifically developed to anticipate materials needs, consider lead times, release purchase orders, and schedule production in accord with a master schedule (23:376).

MRP started out as an ordering system evolving into a priority planning system and finally into a closed loop MRP system. The term "closed Loop" really has two meanings. It means that missing elements in the system like capacity planning, shipment scheduling, and vendor scheduling are filled in. It also means that there must be feedback from the vendors, from the factory, and from the planners whenever there is any problem executing the plan (37:44).

Incorporating the financial and operating system together moved MRP to MRP II. MRP II can be thought of as "a management system based on network scheduling or, simply as organized common sense" (34:3). Technically, it is not much different from closed loop MRP. However, It does include the financial numbers and a simulation capability (37:46).

Manufacturing resource planning (MRP II) systems provide the information flow needed to manage a factory. They include production and inventory control systems for scheduling and materials management as in MRP, but add the information needed from and by engineering, maintenance, accounting, purchasing, sales, and the other functions that

interface with manufacturing (23:274).

The principles of MRP could be used to address the problems, such as determining required ship dates, in managing distribution inventories that are caused by traditional approaches (37:285). Distribution Resource Planning (DRP) is designed to determine the need date for material, keep that need date current, integrate the planning of distribution center replenishment inventories with manufacturing inventories, and put the emphasis on controlling lead times. DRP is simply MRP used in distribution and can easily be integrated with the manufacturing master schedule (37:297). MRP and DRP can be used as a tool enhance the support of R&M objectives.

#### Implications for Transportation

In order to explore the implications of R&M 2000 on Transportation, five investigative questions were proposed that were thought to be representative of the issues that should be considered. The previous sections have examined the possible effect R&M will have on Mobility, the number of spare parts required, and the shipment of those spares. Existing Transportation policy was also examined along with JIT and MRP, MRP II, and DRP systems. This next section attempts to answer the investigative questions based on the research and interviews conducted and reported above.

Investigative Question Number 1. How have DoD and Air Force R&M directives effected transportation policy in the area of traffic management?

According to Mr. Figueroa R&M 2000 has not as yet affected transportation policy and as far as he knows there have been no directives dealing with the subject. He further states that he does not expect any directives or policy changes as a result of the R&M 2000 program. He feels that as requirements change so will transportation to meet those requirements, but basic policy will remain the same (17).

There is, however, a good possibility that some sort of R&M directives may evolve out of the new R&M structure being implemented at HQ AFLC/MM-R. A Functional Management Inspection (FMI) was conducted by AFLC/IG in January 1988 to asses the degree that R&M 2000 had been institutionalized in AFLC. The FMI by report concluded that R&M considerations had not become part of the day-to-day life of the command. There had been no significant fundamental change in the Command's way of doing business as a result of the promulgation of the R&M 2000 program (28:ii). The FMI report further stated:

At none of the installations had the Assistant to the Commander for R&M succeeded in drawing together the MM [Materials Management], MA [Maintenance], PM [Contracting and Manufacturing] PM, and CR [Competition Advocacy] communities into an organization for R&M, with a sense of common mission [28:10].

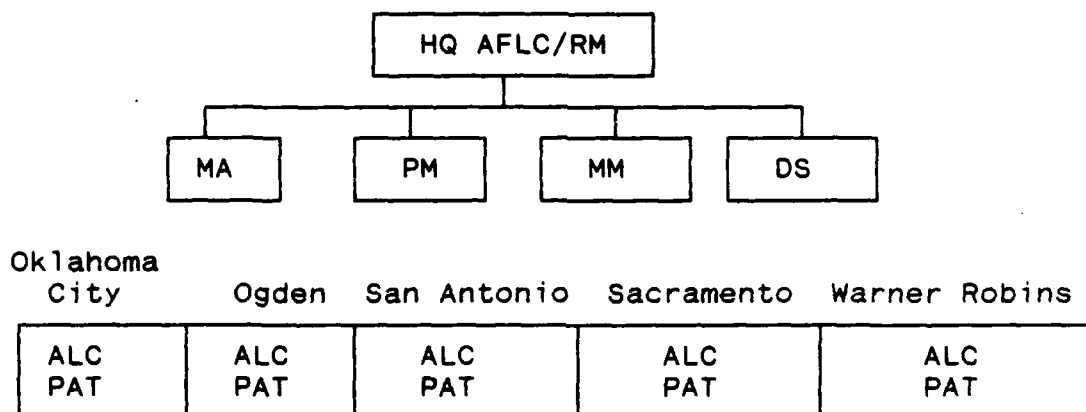


This finding is of concern to the AFLC and R&M communities as a whole. What is even more interesting about this particular finding (from the perspective of this research) is that even the inspection team failed to include the Distribution (DS) community, which includes Transportation, in the finding. In order to remedy this situation, General Alfred G. Hansen, Commander, HQ AFLC, tasked his Assistant for R&M to establish and manage a standing HQ AFLC R&M Process Action Team (PAT). This team will focus the Command's R&M institutionalization efforts/initiatives and manage AFLC R&M policy. MM, MA, PM, and DS will each assign one member to the Process Action Team (18). In addition to the PAT, AFLC/MM-R will be changed to AFLC/RM. There were three basic reasons why the office symbol was changed. First, the MM-R gave the impression that the program was primarily an MM program. Second, the dash indicated a temporary status. Lastly, the R symbol implies that reliability is more important than maintainability. The basic dual hat structure where R&M falls under the direction of MM is still in place but MM-R has be replace by RM (9:5). Each of the Air Logistics Centers will mirror the HQ AFLC/RM Structure (6). Figure 2 shows the structure of the newly formed Process Action Team.

Each of the members of the PAT act as liaison between his/her directorate and AFLC/RM. As issues arise involving their particular area, they will either be able to handle

the issue themselves or be able to bring in the expertise of those actually working in the area in question.

Figure 2. AFLC PROCESS ACTION TEAM (PAT)



Each of the ALC's PAT mirror HQ AFLC's PAT.

Investigative Question Number 2. Have R&M directives and initiatives effected the requirements for expedited shipments?

At the present time it is impossible to tell whether or not expedited shipments have been effected as this is not being tracked by either the transportation functions or the R&M functions (7) (17). However, as discussed earlier, Transportation priorities can be upgraded by changing the UND designator for a particular requisition. As inventory levels decline as a result of the R&M 2000 program it is reasonable to assume that a unit may find it necessary to upgrade their UND as spares run out. Whether spares depletion will occur at a faster or slower rate as a result

of the R&M program will be the driving force behind the need for expedited shipments.

Another fact that supports the idea that R&M 2000 will increase the requirement for expedited shipments as pointed out by Mr. Figueroa, is that lower inventory levels have traditionally meant more transportation is required. This is because there is a trade off between the frequency of shipments and the level inventory. As inventory levels drop, required transportation goes up. Improved reliability should be able to counter this traditional relationship between transportation and inventory by decreasing the utilization rates of a particular spare.

Investigative Question Number 3. Do Air Force transportation managers have any specific R&M programs, and, if so, what are they?

This question goes back to the first investigative question in that as there are no policies regarding R&M and transportation, therefore are no specific R&M programs for Transportation. However, this may not always be the case. As The AFLC R&M PAT begins to exert its influence into the Distribution areas, Transportation may find that some sort of R&M development program may be necessary. This is particularly true for the packaging function of Transportation which has such a direct impact on R&M.

Investigative Question Number 4. What innovations in distribution management are being implemented to enhance R&M objectives?

While there are no particular Transportation or distribution trends specifically developed out of the R&M 2000 process, there have been some changes that have taken place in transportation to enhance availability. For example, the Assured Distribution System (ADS) has been implemented to provide for the logistics capability to distribute/redistribute mission essential spares during peacetime and wartime (22). There are two systems currently in operation; the European Distribution System (EDS) and the Pacific Distribution System (PDS). The basic framework for both of these system consists of dedicated logistics aircraft, forward stockage of wholesale spares, and logistics command, control and communications (LOG-C3). In the EDS, 18, C-23A aircraft were chosen as the dedicated logistics aircraft. RAF Kemble, England was chosen as the first site for the forward stockage warehouse with central and southern region sites yet to be determined. LOG-C3 is designed for logistics command and control of mission essential assets. It is required to make sourcing decisions within two hours and have a system availability of at least 98% plus. The system interfaces with base and theater communications networks and Phase IV (Sperry 1160 computer system). The Defence Data Network (DDN) is primary and

Automatic Voice Network (AUTOVON), PDN (Public Data Network), and PSN (Public Switching Network) as backups. The Pacific Distribution System (PDS) is along the same lines as EDS. However, the aircraft used in for PDS is the C-12 rather than the C-23A. The C-12 was select over the C-23A for PDS because of its extended range necessary to operate the Pacific region (26).

The ADS, while not a pure JIT system, is structured along those same lines. ADS provides Air Force organic capability for intra-theater movement of mission essential spares when common user air/surface cannot provide assured movement within 12 to 36 hours. This differs from a JIT system in that it is still a demand-type of distribution system, where as a JIT system is generally a regularly scheduled system that provides just the number of items to keep an operation/production going until the next scheduled shipment arrives.

Another relatively recent development in Air Force distribution systems is the restructuring of the Logistic Airlift (LOGAIR). LOGAIR is a commercially contracted carrier operation used by the Air Force for movement of high priority material for weapon system support. The LOGAIR concept moves cargo from an origin to a destination via a network of interconnecting, circular routes. This concept fulfills a proven, ongoing need for frequent, dedicated airlift between domestic USAF installations and their

logistic support depots. This network of routes is based upon a trunk and feeder system. The trunks or main lines connect the five Air Logistic Centers (ALCs), the Air Force Logistic Command headquarters and the eight major aerial ports. Feeder lines are subsidiary routes which connect individual user installations with the trunk lines. In the past, six trunk routes and seven feeder routes have been utilized. The current route structure and schedules provide an efficient pattern of services to satisfy near-term needs of most users within the Continental United States (CONUS). (25:40-80) In the late 1970's, the need for an overnight delivery system during peacetime was validated. Originally, the major emphasis was placed on establishing a single hub to be used as a consolidation point for cargo in transit between CONUS locations. It became apparent that the single hub system was cost prohibitive and alternative methods were investigated. (33) (35)

In the early 1980's, personnel at HQ AFLC investigated the possibility of using commercial distribution centers (e.g. Emery Worldwide) for CONUS cargo movement under peacetime operating conditions. At that time, it was estimated that LOGAIR cost were approximately \$.44 per pound of cargo compared to over \$2.50 per pound of Air Force cargo moved by commercial enterprises. Again, due to costs, the proposal was abandoned. (24) (34)

Finally, a modification of LOGAIR called LOG-X was developed and put in to use in January 1988. The primary difference is that aircraft will adhere to a strict timetable to allow overnight delivery on most routes. Minor changes in the number of bases designated LOGAIR terminals were also made; eliminating less frequent stops and adding a series of stops in support of the B-1 bomber. (25) LOG-X is a good example of how transportation system can change as demand changes and weapon systems change.

ADS and LOG-X are only two systems being used by the Air Force to improve support to various weapon systems. LOG-X, like ADS, was not developed with R&M in mind but any improvement in distribution has a indirect benefit to the R&M program.

Investigative Question Number 5. What new developments in distribution management should the Air Force utilize to enhance R&M support?

The first steps have already been taken to enhance Transportation and distributions support of R&M. The new Process Action Team being instituted at HQ AFLC and at the ALC's should go a long way toward developing a total integration of the various disciplines that need to be involved in the R&M process. As of yet, the DS representative on the PAT does not see much in the way of involvement for transportation. However, he does acknowledge the fact that transportation can have a

detrimental effect on R&M if transportation fails to get the spares where and when they are needed (17).

Two areas that deserve consideration for enhancement of the overall distribution system are JIT systems and MRP. While JIT may be inappropriate for base level or intermediate maintenance operation, it maybe quite useful at the depot level were a more steady production operation exists. MRP on the other hand could be used in almost any situation to help plan requirements before they are actually needed.

The area of packaging plays an important role in enhancing R&M support. An item, no matter how reliable, is of little use if it arrives at its destination damaged because of inadequate packaging. Even if an item is packaged correctly, handling after it gets to destination can have a direct impact on overall R&M performance. For example, a gyroscope was shipped to a base in a crate that offered all the required protection it needed. Once at the destination, however, the smaller case inside the crate was removed because it would fit on the warehouse shelf easier than the whole crate. Then when the smaller case containing the gyroscope was moved across base, the gyroscope was damaged because it no longer had the protection of the crate (36). Another packaging issue that could have an impact on transportation is that if the packaging is excessive, it will actually take up more room then is necessary. This



could interfere with two of the R&M objectives or decreasing mobility requirements by taking up more space, and reducing costs as more packaging means more cost.

One individual interviewed felt that if R&M could lead to some kind of standardized packaging it would be a real benefit to transportation because loading would be simplified (16). While standardized packaging may not much to decrease mobility requirements, it would certainly make loading for parts and equipment faster and easier because all to loads would be the same basic size. It may also decrease cost because the packaging would be standardized which could lead to some sort of economies of scale.

#### Summary

When looking at such issues as mobility, number of spares, and the shipment of spares, it is not yet clear what impact the R&M 2000 program will have. It is clear that as R&M 2000 strives towards its objectives that these issues will be affected. Existing Transportation policy deals currently deals with how Transportation priorities are set and there appears to be no directives to change that policy to enhance R&M objectives. Transportation needs to examine new trends in distribution management in order to take a proactive posture in dealing with the effects of R&M 2000. This includes looking at JIT systems as they may relate to the Air Force and examining MRP, MRP II, and DRP systems as well.

As can be seen from the HQ AFLC FMI, R&M 2000 has a long way to go before it becomes fully institutionalized as it was originally intended. Until that happens, support functions such as Transportation will continue to play a reactionary role to any changes that come about as a result of R&M 2000. There have been and are on going projects such as the European Distribution System and LOG-X to help improve the service that transportation provides. However, these systems are being implemented without any apparent input or feed back from the people responsible for implementing R&M 2000. This situation should change with the advent of the AFLC Process Action Team that is comprised of members from MM, MA, PM, and DS. From the answers attained for the investigative questions it appears as though the implications for Transportation from R&M 2000 are not as yet being addressed by either AFLC/RM or by the Transportation community. Most do agree that Transportation has a role to play in the R&M process. The literature reviewed also clearly shows that transportation can have an impact on R&M particularly in the area of packaging and mode of transport.

#### IV. Conclusions and Recommendations

##### Conclusion

The R&M 2000 process is a complex one with a specific set of goals, that if, or when, accomplished could have a direct effect on Transportation. Conversely, transportation could have a direct effect on R&M's ability to accomplish those goals. However, just what this relationship between Transportation and R&M will be is not yet clear. There is almost unanimous agreement among those working with R&M and those in Transportation that transportation's role in the R&M process can have an impact on the success of the program. The underlying problem is that no one, as yet, has considered just what Transportation's role should be.

While Transportation was not mentioned specifically, the HQ AFLC FMI did point out a problem with the institutionalization of R&M 2000 throughout the command. The Process Action Team that has been formed is a first step in bringing in the ideas of other support functions such as Distribution into process. The total integration of the R&M 2000 process stems from the reality that reliability does not stop at the engineering level but must be tracked all the way to the ultimate user. Measurements such as mean time between failures (MTBF) and mean time to repair (MTTR) are meaningless if an item never gets put into service.

because it is damaged in shipment because the packaging was inadequate for the mode of transportation chosen to ship the item. MTTR can go up unnecessarily if a weapon system is waiting on a critically needed part being shipped via an efficient or antiquated distribution system.

Transportation has not stood idly by with no concern about improving the service it provides. The Assured Distribution System (ADS) is an excellent example of how an improvement in distribution and transportation can increase availability, which is a goal of the R&M program. However, when ADS was being put together, R&M was not being considered, and today R&M is still not a player in how decisions dealing with ADS are made.

The overall conclusion is that the R&M 2000 program is a viable program that is growing in its influence on how the Air Force views system and component acquisition and support. However, the importance and acceptance of R&M outside the circle of those working directly with the program is lacking. Also, those working with R&M have a limited view of what constitutes R&M. This has inhibited the institutionalization of the program. Because of this shortcoming in the R&M program, the implications of R&M 2000 on transportation are not readily apparent.

### Recommendations

In order to better understand the relationships between R&M and Transportation, Three recommendations are in order.

First, use the R&M Process Action Team to continually bring in those support functions that are not normally associated with R&M in order to get their ideas and input into the process. R&M, in order to be successful, must take on a 'cradle to the grave' characteristic that plans for R&M from the design stage to the deployment stage. In order to do this, the thoughts and ideas of the support functions are essential.

This will allow for implementation of the second recommendation, which is for transportation managers to express their concerns regarding R&M and its impact on transportation to those working in the R&M field. Engineers do not always look past the MTBF or MTTR when looking at R&M. The new PAT developed at AFLC should be an excellent forum for voicing these concerns. Because of the lack of institutionalization, transportation and distribution managers have not really felt a part of the R&M process. As a result, many have not even heard of R&M, let alone developed any concerns about how it will effect them.

Finally, the Transportation planning functions at all levels should preform a transportation audit as suggested by Transportation Strategies for the Eighties (32) in the literature review in chapter one. It does not appear that R&M 2000 is a driving force in changing the way transportation does business but definitely is one of the key strategic issues that should be considered. This will

allow planners to evaluate the present transportation and distribution system against the key strategic issues that may require a change in the present system. New systems such as JIT systems and MRP II need to be looked at closely for their possible applicability to Air Force needs. This of course requires transporters and distribution managers to become proactive rather than reactive when it comes to changes brought about by R&M or any other issue.

#### Recommendations for Future Work

The study of R&M implications on transportation is by no means complete. This research provides the foundation for continued study and investigation. The Following list suggests potential areas for future research:

1. Monitor the progress of the AFLC Process Action Team in its efforts to institutionalize the R&M 2000 Program. In particular, report the effects the PAT has on transportation and other support functions.
2. Investigate the effects packaging has on reliability and its effect on over all costs.
3. Monitor the effect R&M has on the need for expedited shipments by taking a sample of items targeted as being R&M sensitive.
4. Investigate the possibility of applying R&M principles in order to develop a more reliable and maintainable transportation and distribution system.

Logistics support must be considered on an equivalent basis with engineering and design. Part of this support is Transportation. It is a major factor in logistics support and as such has an impact and is impacted by R&M. Only

through proper integration of Transportation with the R&M 2000 program can the objectives of R&M hope to be achieved and Transportation hope to support those objectives.

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The object of this research is to provide a comprehensive overview of the Air Force Reliability and Maintainability (R&M 2000) Program's effect on Transportation in the area of Traffic Management and to look into future distribution trends to suggest areas of opportunity for Transportation to enhance its support of the systems subjected to the R&M 2000 process.

This study encompasses the impact of R&M on Air Force Traffic Management policy, attitudes, techniques, and issues. In addition to examining the changes being brought about by the R&M 2000 program, some of the developments in transportation and logistics management that are occurring parallel to the R&M 2000 program are also discussed.

Results of this investigation indicates that the institutionalization of the R&M 2000 program has not progressed to the level needed to influence Transportation policy. AFLC has created a Process Action Team (PAT) to address this situation. The characteristics of the PAT are discussed, along with relatively recent developments in distribution and Transportation, such as the European Distribution System (EDS) and LOG-X.

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